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January 26, 2016

Milwaukee County Fleet Management Division
Attn: Arnold Freeman
10320 W Watertown Plank Rd
Milwaukee, WI 53226

Subject: **Milwaukee County Fleet Garage – Condition Assessment Report**
10320 W. Watertown Plank Road, Milwaukee, Wisconsin
ZS Project No.: 7523

Dear Mr. Freeman,

The following is a report of the ZS assessment of the main roof systems at the Milwaukee County Fleet Management maintenance and vehicle storage garage in Milwaukee, Wisconsin.

INTRODUCTION

ZS LLC (ZS) was retained by Milwaukee County, the Fleet Management Division. The fleet garage is a maintenance/vehicle storage facility located at 10320 W Watertown Plank Road in Milwaukee, Wisconsin. The scope of the roof assessment included a visual survey of the roof areas and a roof moisture survey performed using an Infrared (IR) camera. This report provides a summary of our findings and conclusions, and outlines our repair recommendations.

BACKGROUND

The fleet garage building is a one-level structure that includes vehicle parking, long term vehicle storage, road works and street signage storage, repair and maintenance facilities, and offices. The building was constructed in 1970. Based on our assessment, the roofs consist of light weight acoustical roof deck panel (Tectum), with a nailed base sheet, multiple layers of insulation and a coal tar pitch built up roof system and a gravel surface. The roof areas consist of a main roof divided into four quadrants (Roof Areas 1-5), and a lower roof over the office areas (Roof Area 5).

VISUAL OBSERVATIONS

ZS was on site to make visual observations. A roof plan including identified defects is included in Appendix A.

Interior Survey

ZS performed a visual survey of the interior/underside of the visible portions of the roof deck. The following is a summary of the observations:

- Water stains and spalling observed on the underside of the Tectum roof deck in the storage area (Figures 1-2).
- Water stains and evidence of leakage was observed on the ceiling of the mezzanine storage area in the southwest corner of the building (Figures 3-4).

Roof Visual Observations

ZS performed a visual survey of the main roof area and the lower roof area. In addition to the summary of observations noted below, Appendix A identifies the locations and types of observed deficiencies as recorded during our site observations. The following observations were made:

- Numerous moderate to severe blisters were observed in various areas across the entire field of the roof system (Figures 5-6).
- Ponding water was present in various areas across the entire field of the roof system (Figure 7).
- Exposed bitumen displayed severe deterioration including surface cracking and bubbling of the membrane (Figures 8-9).
- Multiple large patches were observed in the roof system (Figures 10-11).
- Large areas of the roof system are missing gravel surfacing and feature exposed bitumen (Figure 12).
- Multiple vent penetrations lack appropriate flashing (Figure 13).
- Multiple roof drain covers were observed either broken or missing (Figure 14).
- Multiple punctures and failure points were observed in the membrane (Figures 15-18)

INFRARED SURVEY

ZS performed an IR survey of the main roof areas of the building, including the underside of the roofs as observed from the interior of exposed decking. The outside weather conditions were 44 degrees F and 80% RH at 4:00 pm during the survey. The survey was performed using a FLIR model T420 Thermacam camera. Infrared thermography is frequently used to identify thermal anomalies in roofing systems, which can also help to reveal areas of moisture within thermal insulation, air leakage in the system, or thermal bridges. The method relies on the use of the IR camera to initially detect thermal differentials in the infrared spectrum and subsequently check actual conditions by making inspection opening in selected locations. The IR camera measures emitted radiation in the infrared spectrum to produce visual images of the subject roof system or underside of the roof deck.

A summary of the survey findings is as follows:

- Thermal anomalies were observed at multiple locations in the field of the roof. Large areas of thermal anomalies were observed in various locations under various conditions, often but not always corresponding to areas of puddling water. See Appendix B for locations and photos (Figures 19-55) for the thermal anomalies.

INSPECTION OPENINGS

ZS observed and documented roof inspections openings. The openings were created and patched by Langer Roofing and Sheet Metal, Inc. A total of (6) inspection openings at various locations throughout the field of the roof were made. These locations are shown in in Appendix B. A summary of the survey findings is as follows:

- Openings 1,3,4,5,6 were made at areas of suspected wet insulation based on the IR survey. All displayed saturated insulation and fiber board topping. See Figures 56-58.

- Opening 4 also revealed ponding water beneath the insulation and above the tectum deck base layer (Figure 59).

- Opening 2 was made at an area of suspected dry insulation based on the IR survey. This location showed no sign of moisture and was dry (Figure 60).

- Opening 6 revealed a joint between wet and dry fiber board topping sections, however the insulation beneath was saturated with water throughout the entirety of the opening (Figure 61).

DISCUSSION/CONCLUSIONS

- The roof system at the fleet garage building is deteriorated and in poor condition.
- Active water leakage is occurring through the roofing system and has saturated the insulation below the system in at least 25% of the area.
- Moisture in the roof system is more severe than interior leakage indicates. The base layer of the roof system is preventing interior leakage while holding water within the roof system above.
- Tectum decking is extremely vulnerable to deterioration due to exposure to moisture. Replacement is recommended before significant decking damage occurs.
- The roof areas 1-5 are deteriorated and are recommended for replacement within the next 12-18 months. Phasing of the roofs by area is possible however extensive repairs are recommended for roofs to remain longer than the 12-16 months.

RECOMMENDATIONS

Replacement of the roofs at the Milwaukee County fleet garage is recommended as follows:

1. Remove existing roof system down to existing structural deck.
2. Evaluate and repair/replace structural roof deck as required.
3. Install new nailed base sheet layer.
4. Install new multiple layers of staggered insulation boards.
5. Install tapered insulation layer for positive slope to drain.
6. Remove and install to sheet metal at roof edges.
7. Install new base and penetration flashings.
8. Install new coverboard.
9. Install new roof system. Roof system options include:
    a. 2 ply modified bitumen system with liquid membrane flashings.
    b. 4 ply asphalt built-up roof system with gravel surfacing.
    c. Single ply fully adhered EPDM membrane.

Roof Area Priorities

The roof areas at the Milwaukee County Fleet garage are in a similar level of deterioration however the following is ZS recommendation for roof area priorities (from highest priority to lowest priority) based upon the assessment:

1. Area 1
2. Area 3
3. Area 4
4. Area 2
5. Area 5

Additional Recommendations/Considerations

1. Prepare a safety audit of roof fall protection requirements and provide design of fall protection system in conjunction with roof replacement.
2. Coordinate new roof drains replacement project in conjunction with roof replacement to accommodate changes in roof thickness and height of drains.

FIGURES

Figure 1: Water stain and spalling on roof deck interior.

Figure 2: Water stain and spalling on roof deck interior.

Figure 3: Water stains and leakage in interior ceiling.

Figure 4: Water stains and leakage in interior ceiling.

Figure 5: Blisters in roof membrane.

Figure 6:Blisters in roof membrane.

Figure 7: Ponding water.

Figure 8: Exposed bitumen.

Figure 9: Exposed bitumen.

Figure 10: Patches in roof system.

Figure 11: Patches in roof system.

Figure 12: Exposed bitumen and ponding water.

Figure 13: Vent with missing flashing

Figure 14: Missing drain cover.

Figure 15: Punctures/failures in roof system.

Figure 16: Punctures/failures in roof system.

Figure 17: Punctures/failures in roof system.

Figure 18: Punctures/failures in roof system.

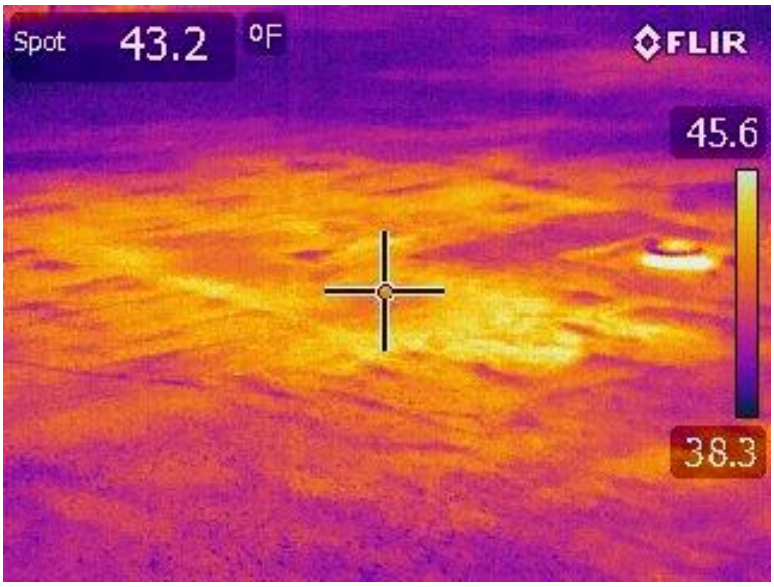


Figure 19: IR Image with thermal anomaly.

Figure 20: Roof area at thermal anomaly.

Figure 21: IR Image with thermal anomaly.

Figure 22: Roof area at thermal anomaly.

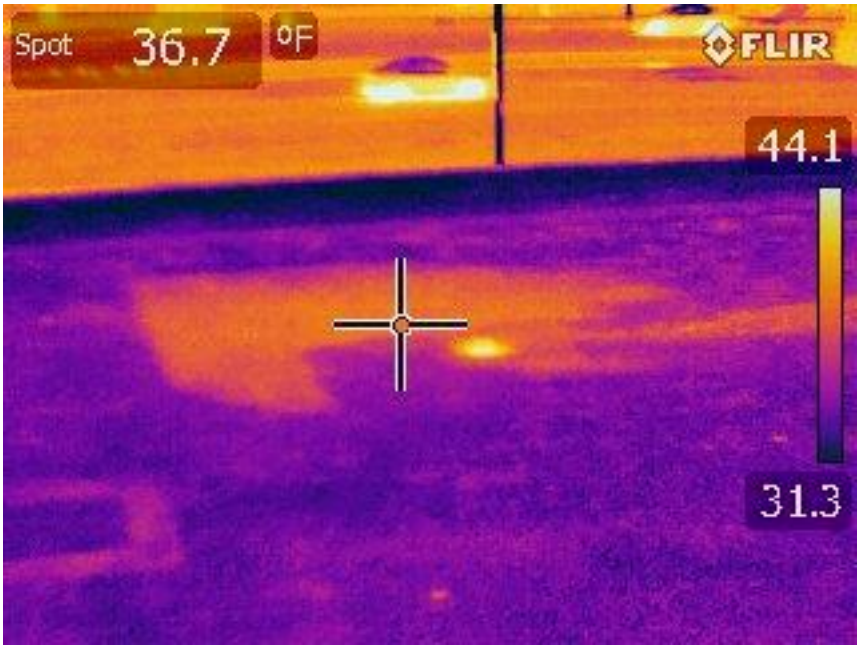


Figure 23: IR Image with thermal anomaly.

Figure 24: Roof area at thermal anomaly.

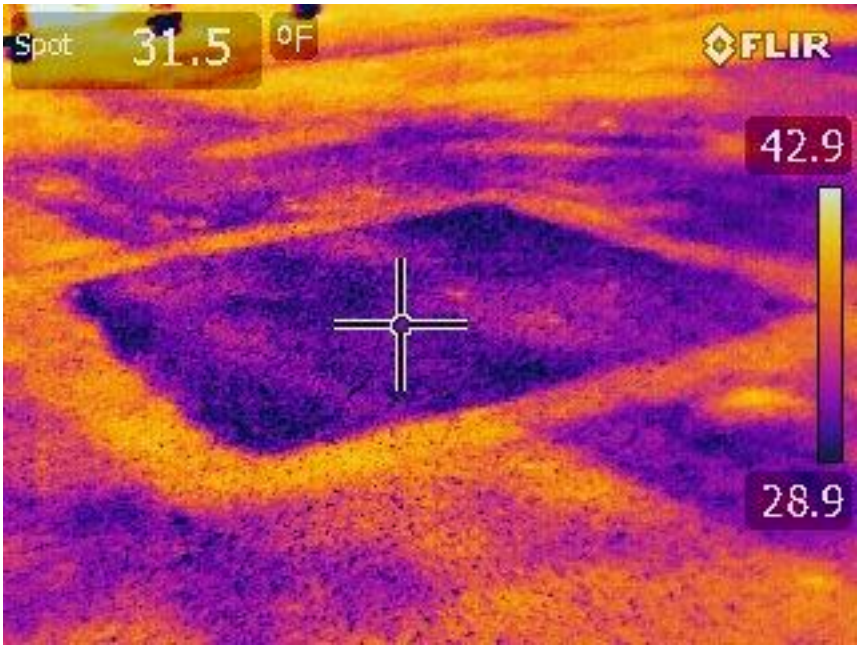


Figure 25: IR Image with thermal anomaly.

Figure 26: Roof area at thermal anomaly.

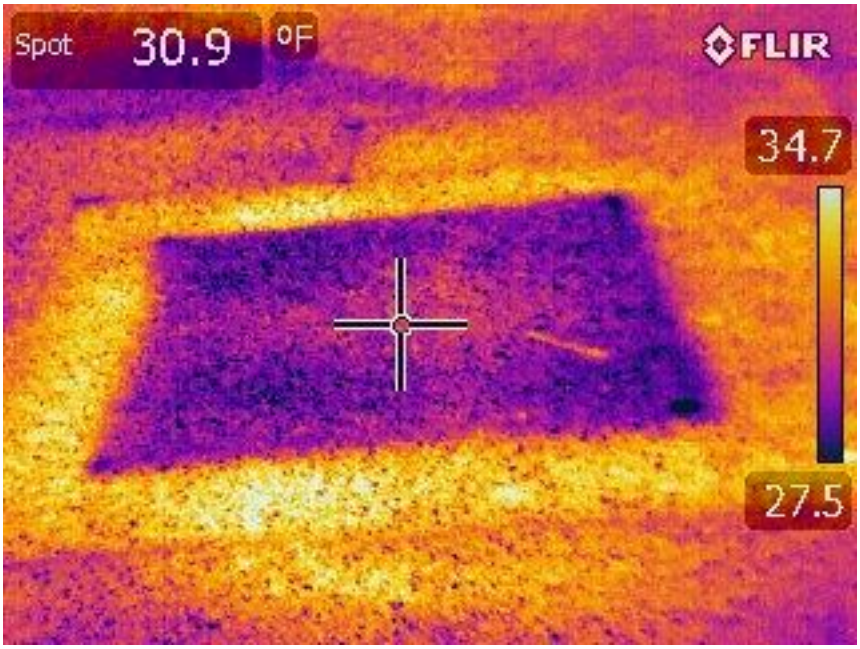


Figure 27: IR Image with thermal anomaly.

Figure 28: Roof area at thermal anomaly.

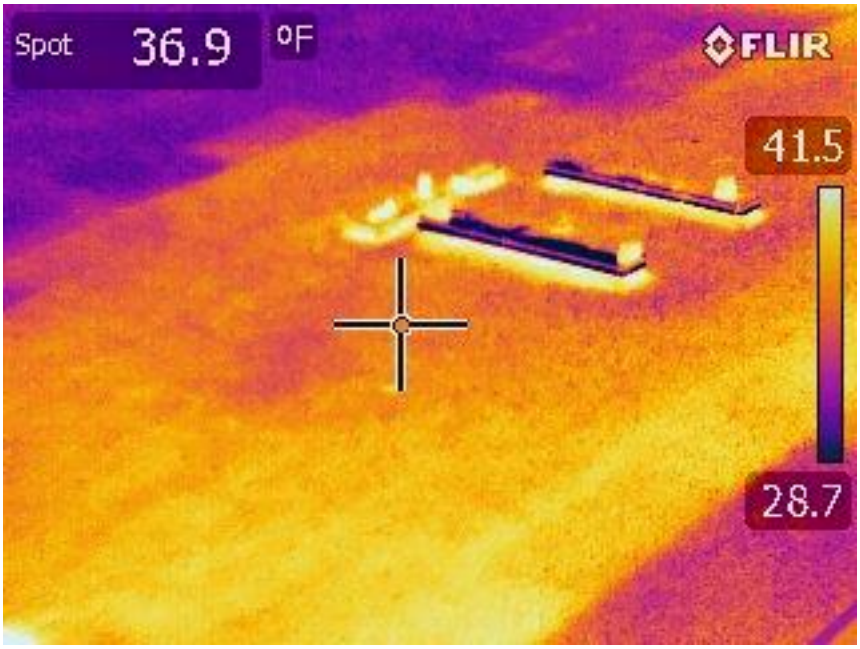


Figure 29: IR Image with thermal anomaly.

Figure 30: Roof area at thermal anomaly.

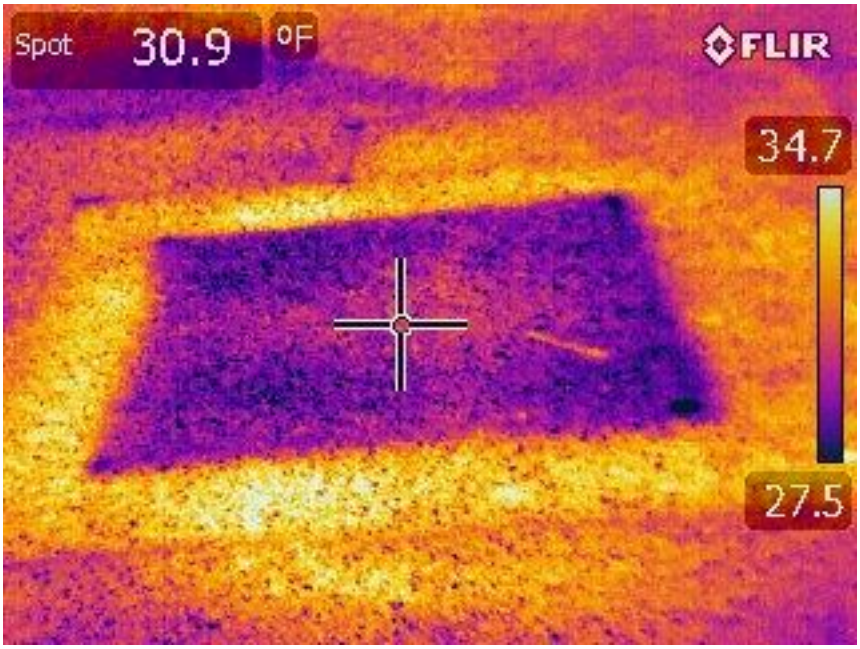


Figure 31: IR Image with thermal anomaly.

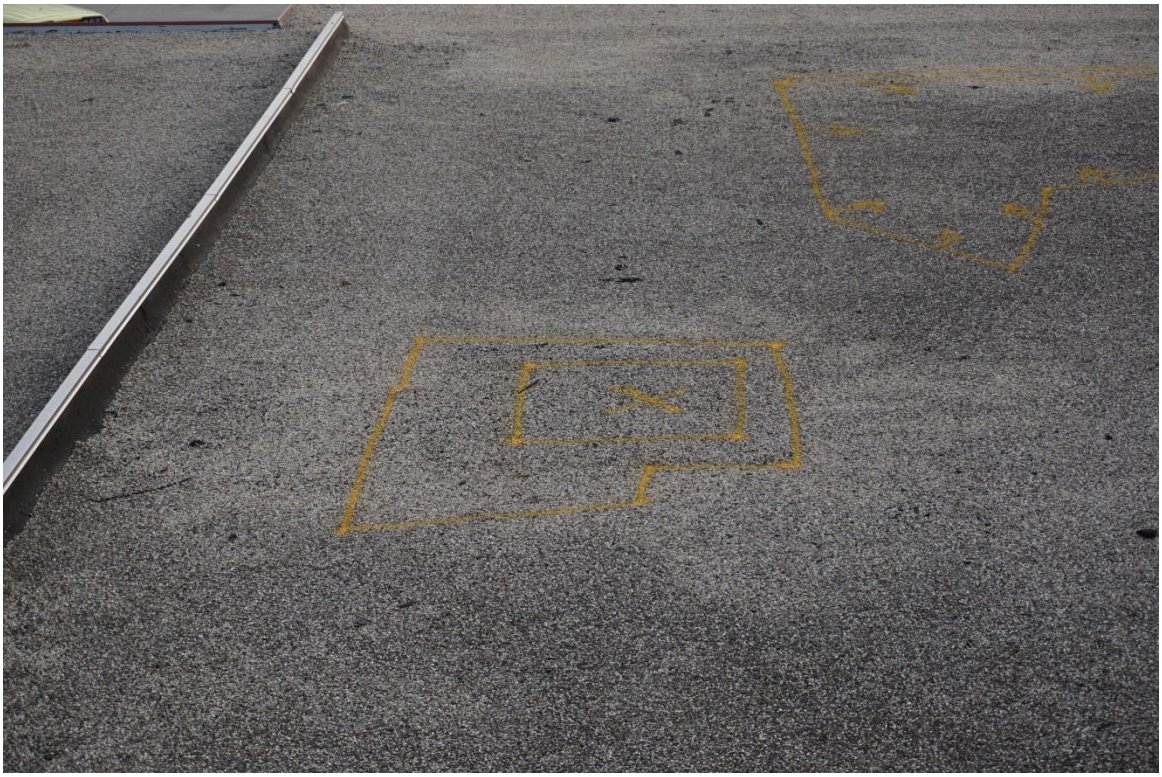


Figure 32: Roof area at thermal anomaly.

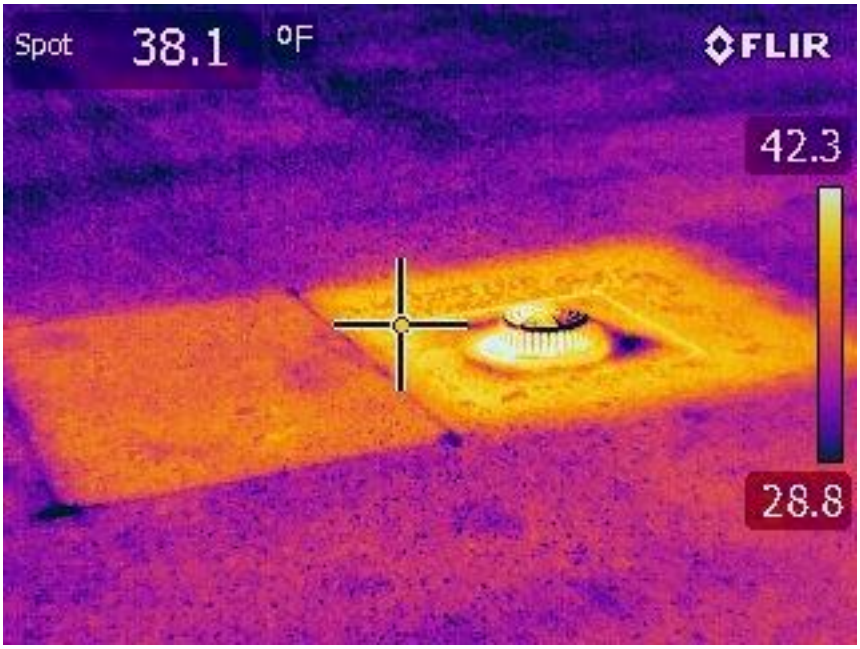


Figure 33: IR Image with thermal anomaly.

Figure 34: Roof area at thermal anomaly.

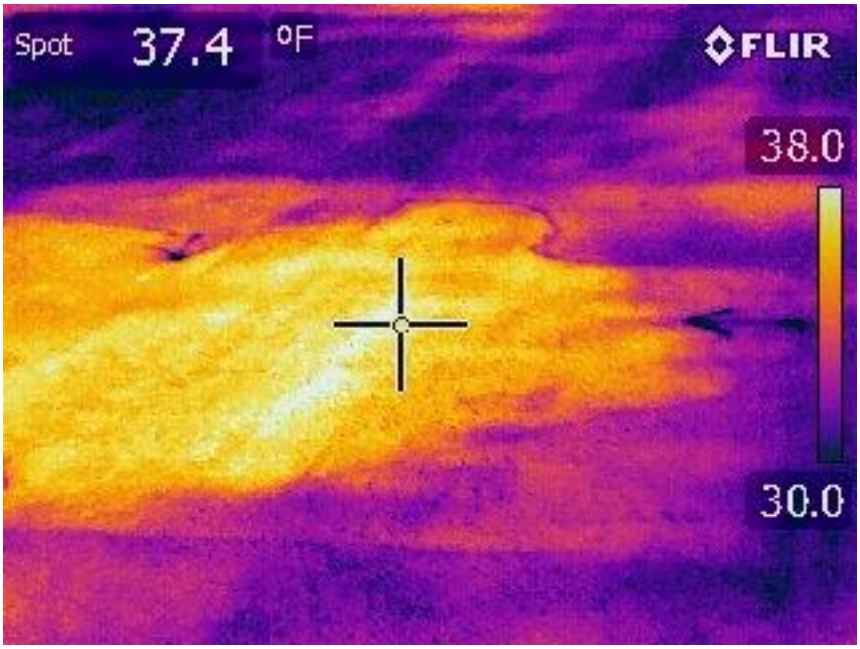


Figure 35: IR Image with thermal anomaly.

Figure 36: Roof area at thermal anomaly.

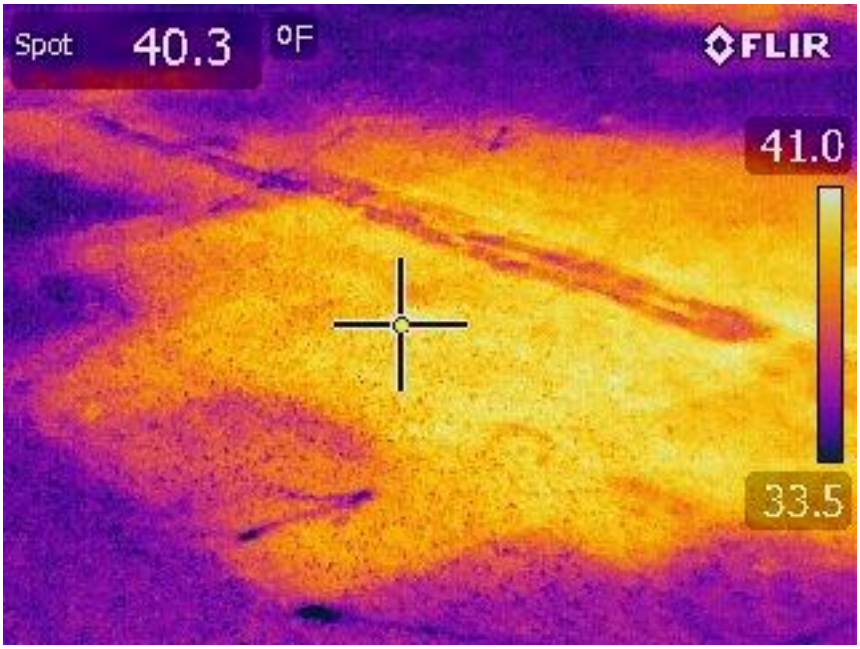


Figure 37: IR Image with thermal anomaly.

Figure 38: Roof area at thermal anomaly.

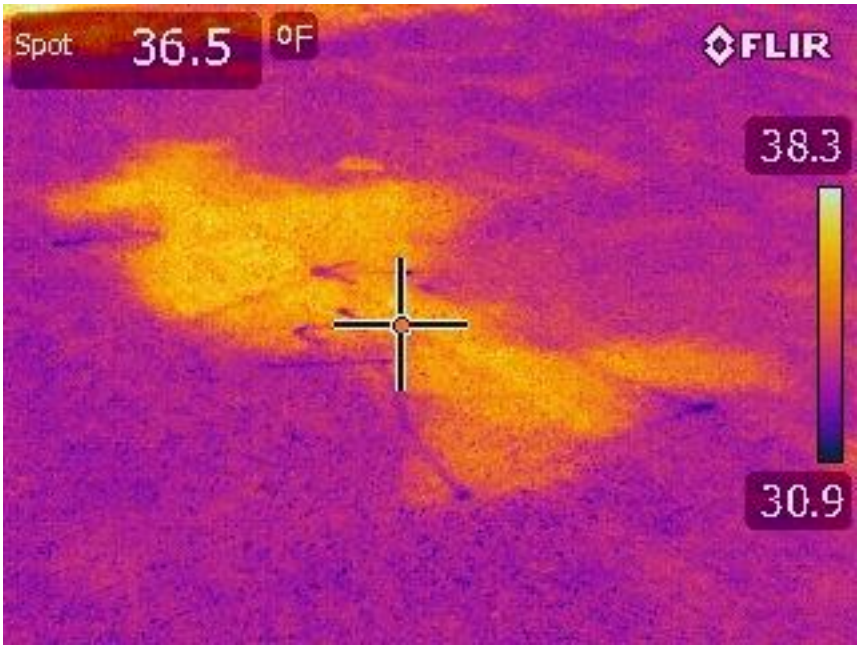


Figure 39: IR Image with thermal anomaly.

Figure 40: Roof area at thermal anomaly.

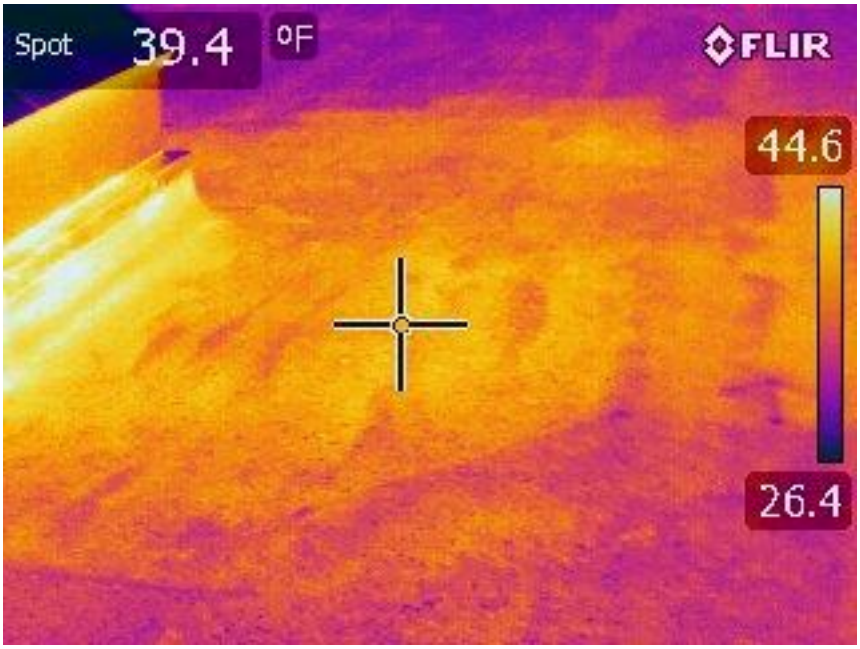


Figure 41: IR Image with thermal anomaly.

Figure 42: Roof area at thermal anomaly.

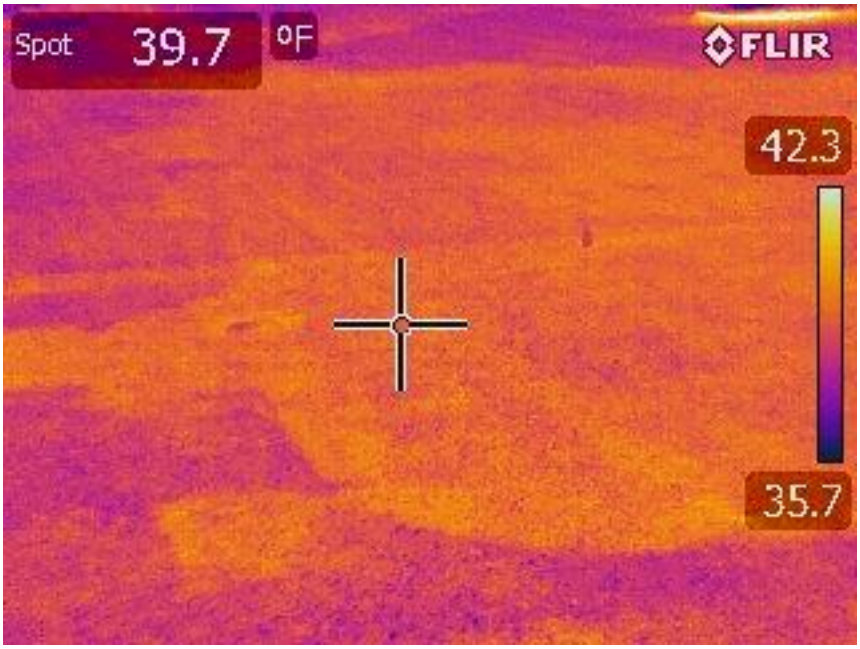


Figure 43: IR Image with thermal anomaly.

Figure 44: Roof area at thermal anomaly.

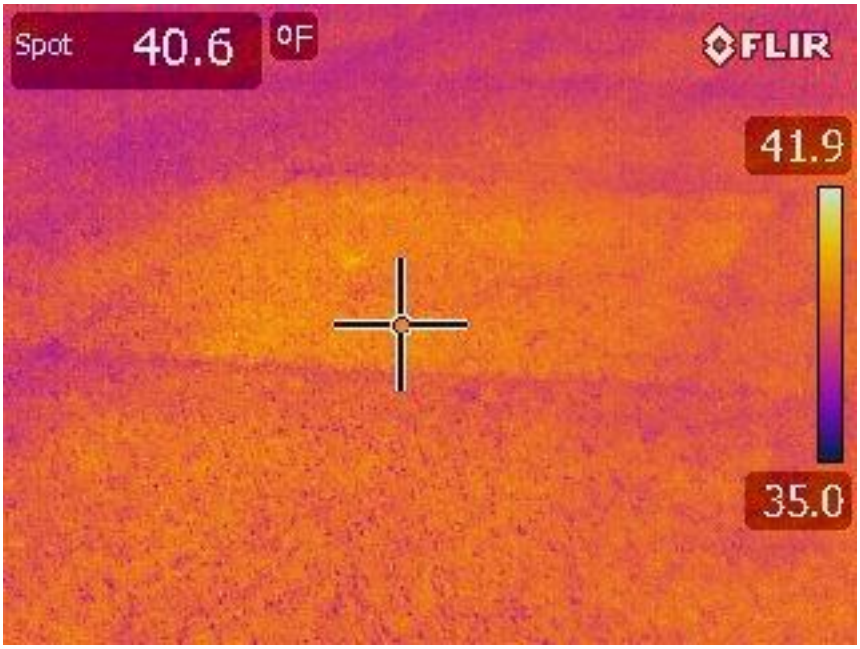


Figure 45: IR Image with thermal anomaly.

Figure 46: IR Image with thermal anomaly.

Figure 47: Roof area at thermal anomaly.

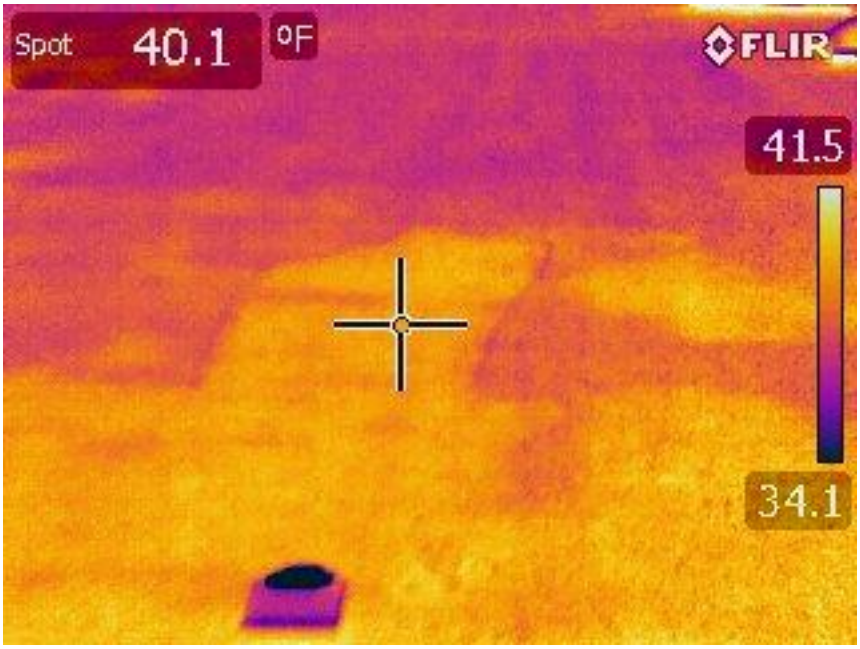


Figure 48: IR Image with thermal anomaly.

Figure 49: Roof area at thermal anomaly.

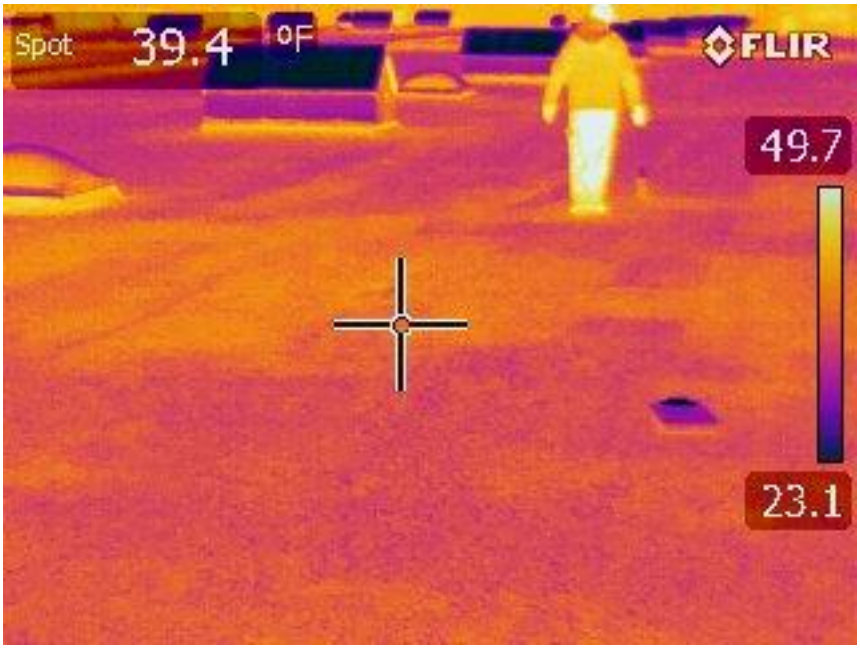


Figure 50: IR Image with thermal anomaly.

Figure 51: Roof area at thermal anomaly.

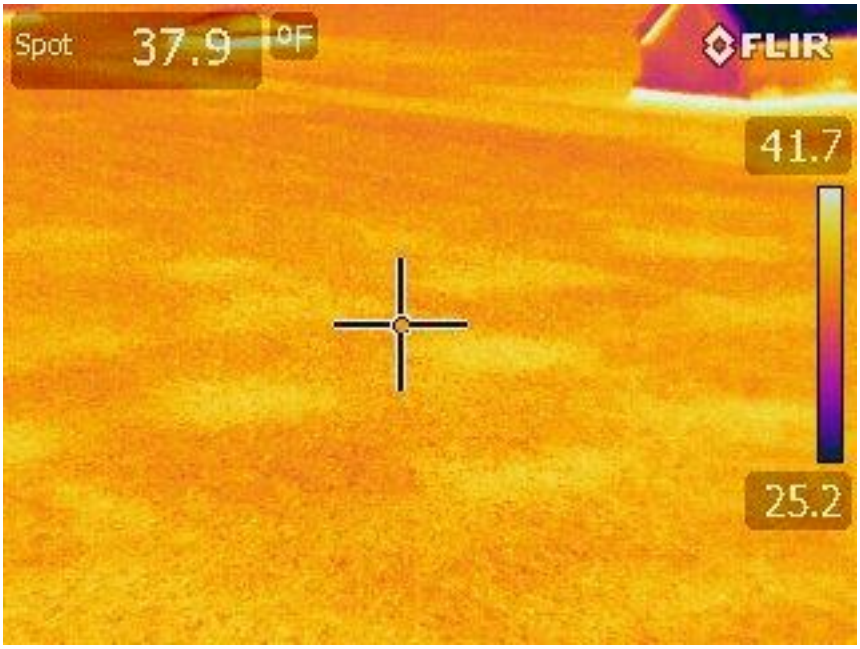


Figure 52: IR Image with thermal anomaly.

Figure 53: Roof area at thermal anomaly.

Figure 54: IR Image with thermal anomaly.

Figure 55: Roof area at thermal anomaly.

Figure 56: Roof Inspection Opening.

Figure 57: Roof Inspection Opening.

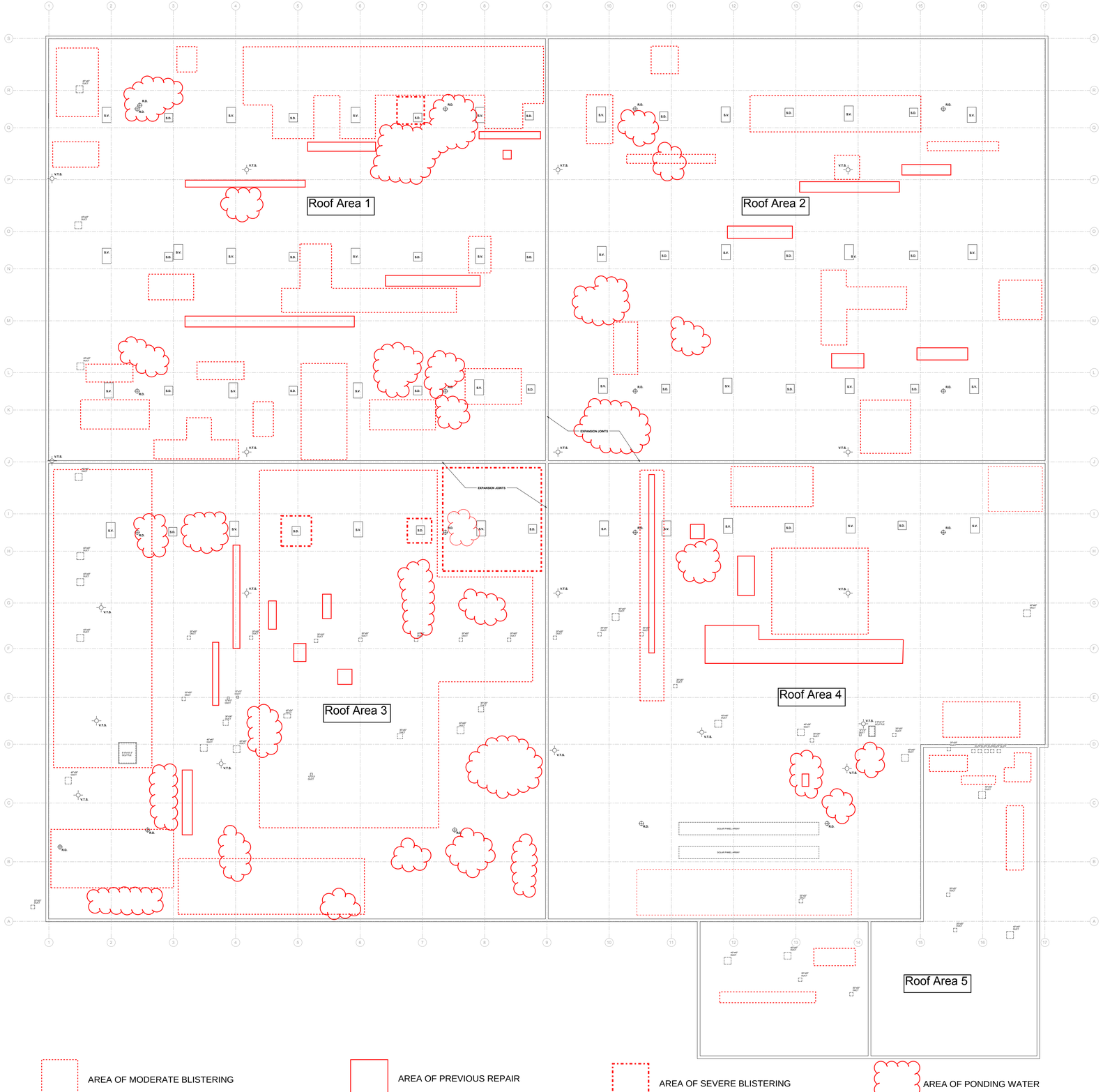
Figure 58: Roof Inspection Opening.

Figure 59: Roof Inspection Opening.

Figure 60: Roof Inspection Opening.

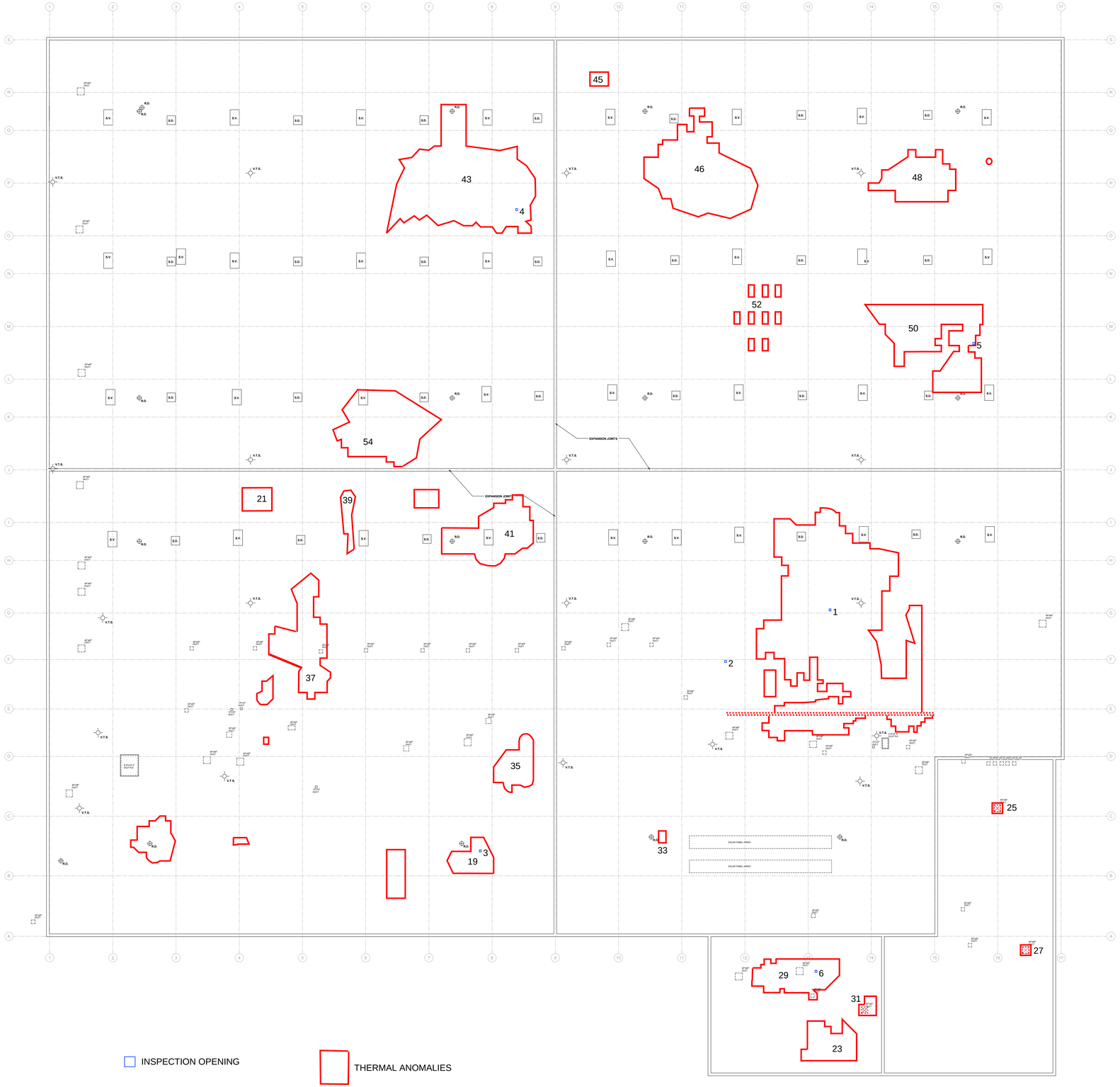
Figure 61: Roof Inspection Opening.

Appendix A-Roof Plan and Visual Observations



Appendix A-Roof Plan and Visual Observations

Appendix B-Roof Plan and IR Moisture Survey



Appendix B-IR Moisture Survey